

# Chapter 3: Numeric Nutrient Criteria Development for Florida Estuaries



*Presented by:*  
**Dr. James D. Hagy III**  
**US EPA NHEERL Gulf Ecology Division**  
**Gulf Breeze, FL**

**EPA Science Advisory Board**  
**December 13–14, 2010**  
**Washington, D.C.**

# Outline

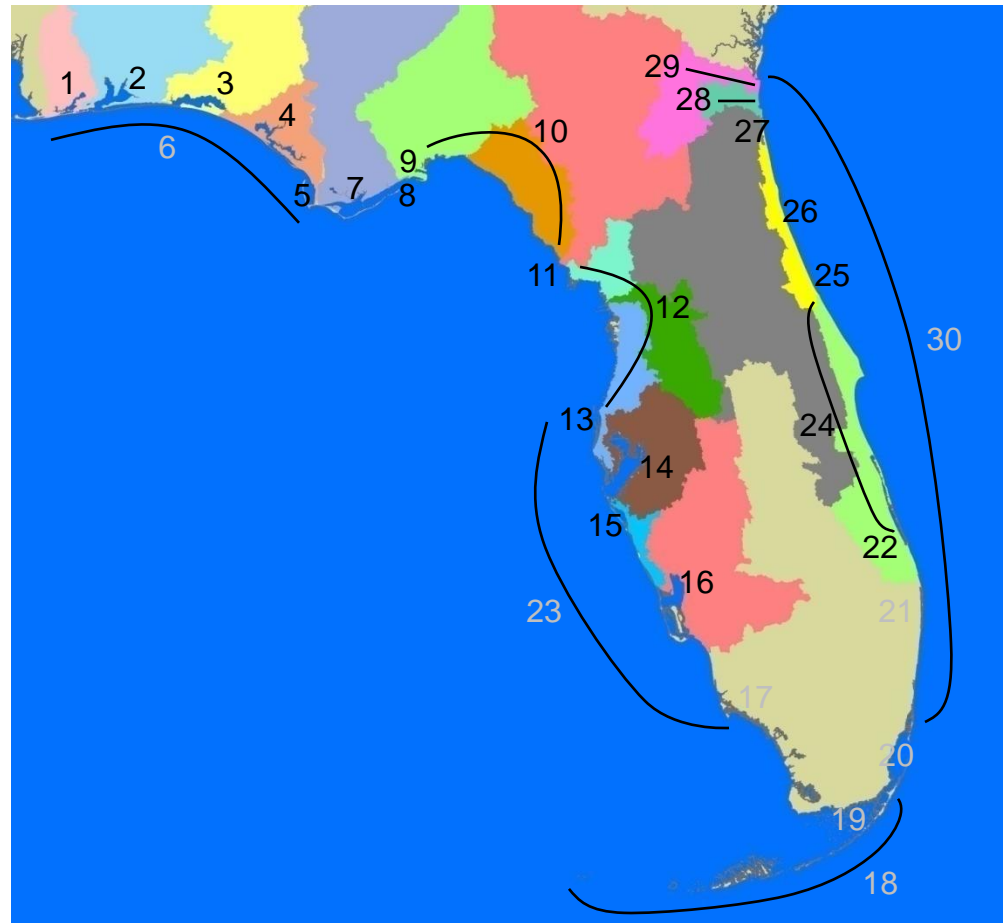
- Delineating Florida's Estuaries
- Biological Endpoints and Indicator Variables
- Approach for Criteria Development
- Data Sources



White Pelicans at Cedar Key, Big Bend Region

# Florida's Estuaries and Coastal Waters

- 1 Perdido Bay
- 2 Pensacola Bay
- 3 Choctawhatchee Bay
- 4 St. Andrews Bay
- 5 St. Joseph Bay
- 6 Emerald Coast (Coastal)
- 7 Apalachicola Bay
- 8 Alligator Harbor
- 9 Ochlockonee Bay
- 10 Big Bend/Apalachee Bay
- 11 Suwannee Sound/Cedar Keys
- 12 Springs Coast
- 13 Clearwater Harbor/St. Joseph Sound
- 14 Tampa Bay
- 15 Sarasota Bay
- 16 Charlotte Harbor
- 17 Rookery Bay / Southwest Shelf (South)
- 18 Florida Keys (South)
- 19 Florida Bay (South)
- 20 Biscayne Bay, Barnes Snd, Card Snd (South)
- 21 Lake Worth Lagoon / Loxahatchee Bay
- 22 St. Lucie Estuary
- 23 West Florida Shelf (Coastal)
- 24 Indian River Lagoon
- 25 Halifax River
- 26 Guana, Tolomato, Matanzas, Pellicer
- 27 St. John's River Estuary
- 28 Nassau River / Big Talbot
- 29 St. Marys River / Amelia River
- 30 Atlantic Coast (Coastal)



Grayed areas not addressed in this chapter

# Delineating Florida Estuaries

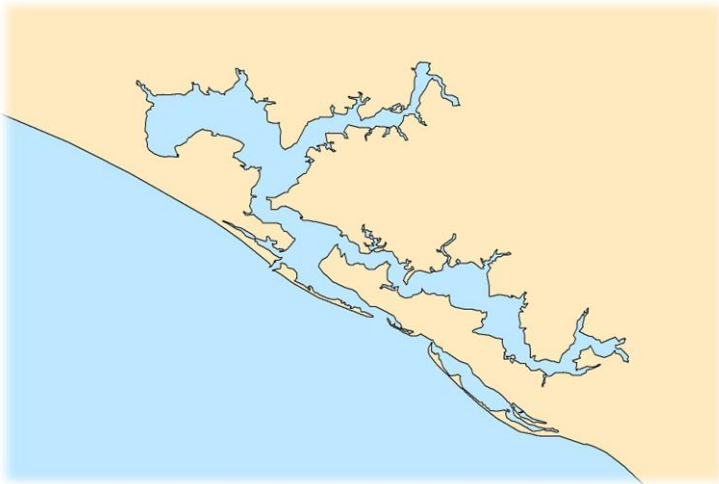
“An estuary is a semi-enclosed coastal body of water, which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage.”

—*Pritchard (1967)*

- Where do “streams” end and estuaries begin.
  - Pritchard’s definition indirect in this regard.
  - Florida’s definition: an average surface water chloride concentration greater than 1,500 mg L<sup>-1</sup>
  - Salinity ~2.7
- Where do “estuaries” end and “coastal waters” begin.
  - EPA could mostly rely on geographic limits of “semi-enclosed” basins.
  - Some basins may be more challenging.

# Delineating Estuaries

“An estuary is a semi-enclosed body of water, connected to the open sea, defined at the upstream limit by average salinity equal to 2.7 and at the seaward margin by the natural limits of the semi-enclosed basin”



St. Andrews Bay



St. Mary's River

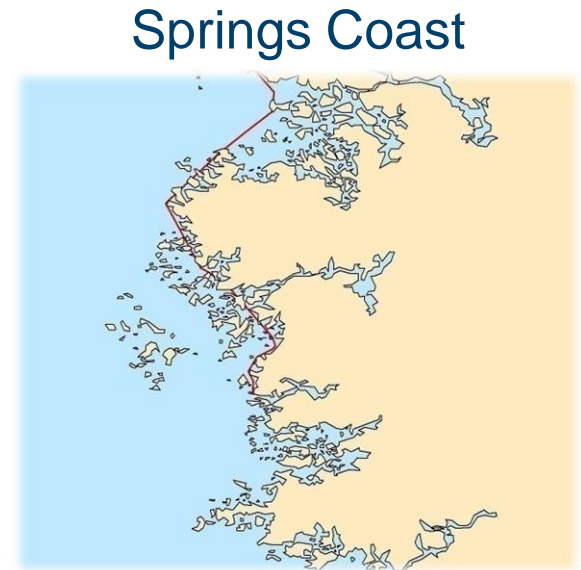
# Delineating Estuaries



Relatively Open  
Mouth



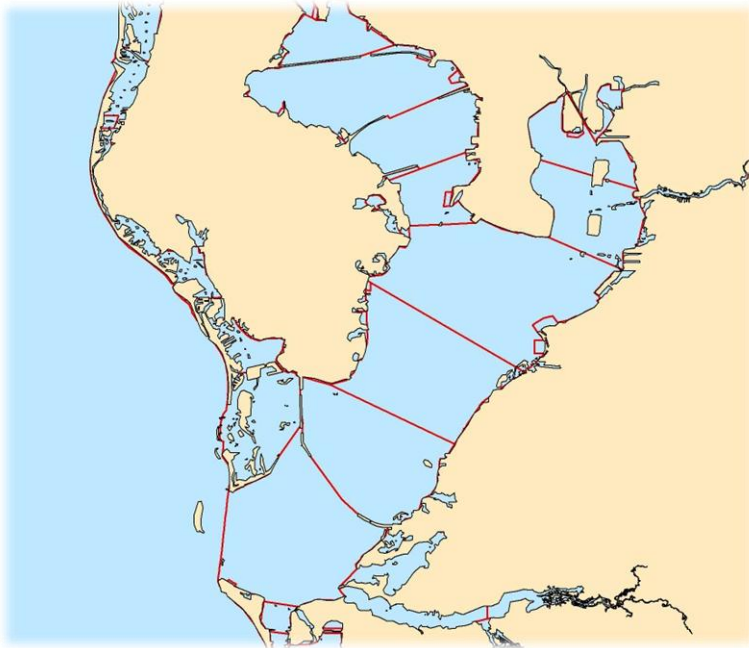
Brackish water is  
largely offshore



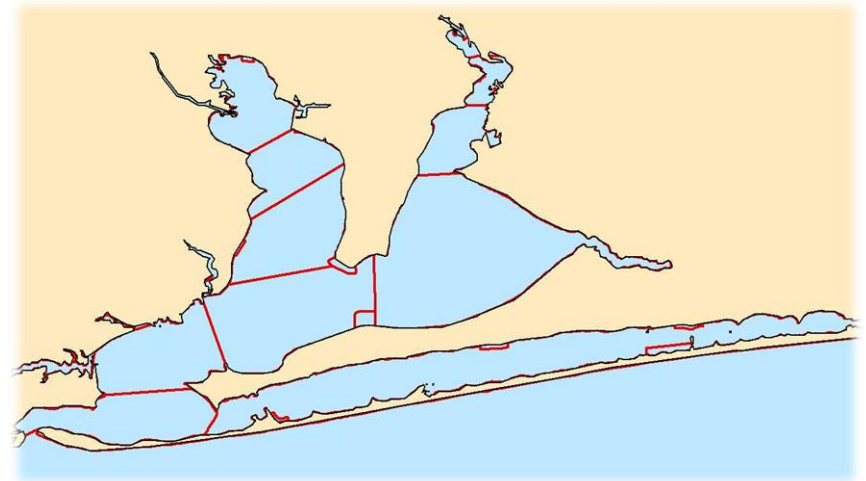
Complex shoreline  
blends from inshore  
to offshore

# Estuarine Segmentation

- Addresses presence of natural water quality gradients within estuaries
- FDEP's Water Body Identification (WBID) System



Tampa Bay

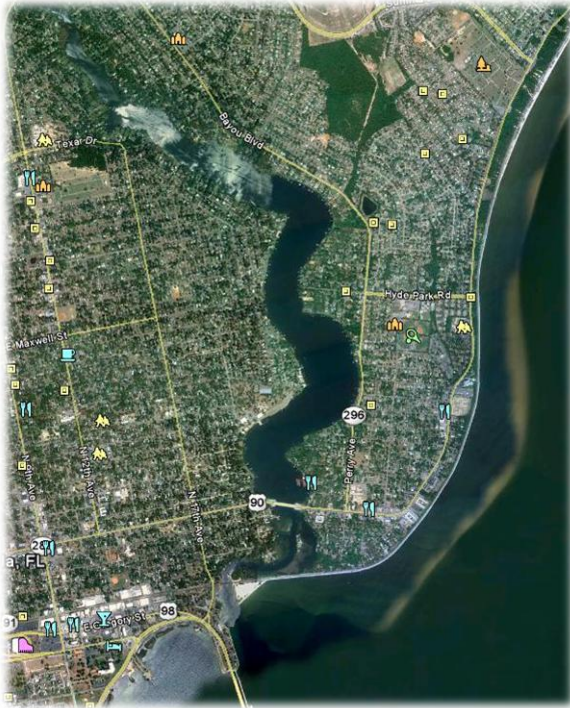


Pensacola Bay

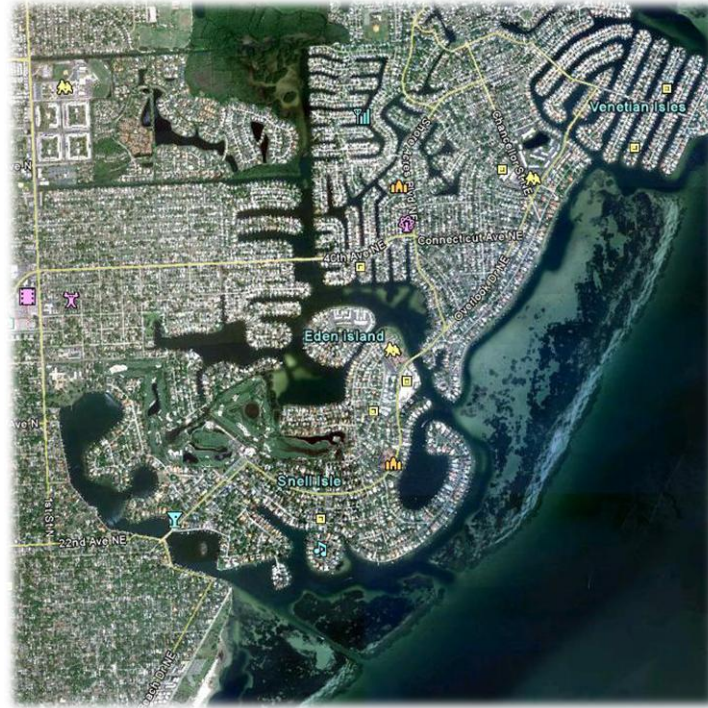


# Estuarine Segmentation

- Estuarine Creeks and Bayous vs. Open Water Areas



Bayou Texar,  
Pensacola Bay



Coffeepot and Smacks Bayous  
Tampa Bay

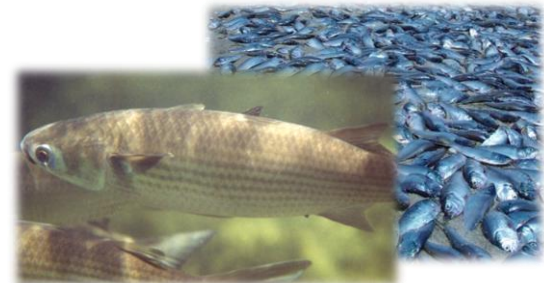


# Selection of Endpoints and Indicator Variables

- Healthy Seagrass Communities
- Balanced Phytoplankton Biomass and Production
- Balanced Faunal Communities

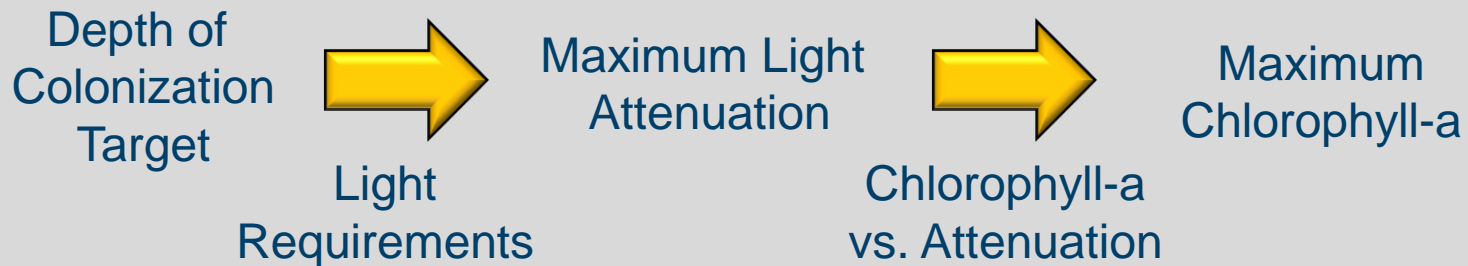
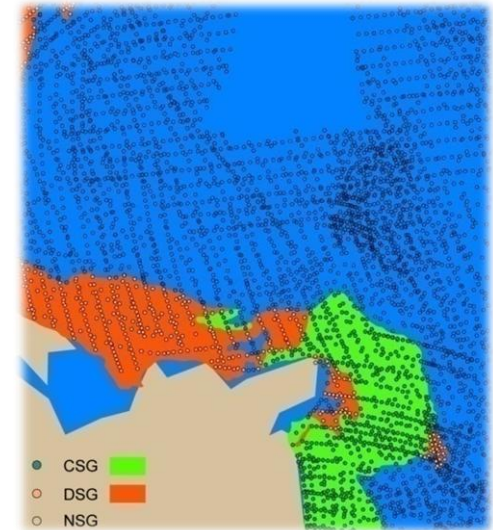


Janessa Cobb, FL FWC



# Healthy Seagrass Communities

- High habitat value. Support aquatic life uses of estuaries. Sensitive to nutrients.
- Depth of colonization.
- Relate colonization depth targets to chl-a limits.
- Relate chl-a limits to nutrient limits.



# Numeric Criteria Development

## Criteria Development Approaches:

- Reference Condition Approaches
- Stressor-Response Models
- Water Quality Simulation Models



# Reference Condition Approaches

- Most applicable:
  - **Historical Reference Condition:** Data available from a minimally-impacted reference period. May be the present.
  - **Comparative Reference Condition:** Similar estuary has data for a minimally-impacted reference period.
- Least applicable:
  - Little data except after nutrient impacts.
  - No similar estuary, or they are all impacted similarly.
- What EPA is considering:

Reference condition approaches may be most applicable for Florida estuaries where existing water quality supports a balanced natural population of aquatic flora and fauna.

# Stressor-Response Models (Regression Models)

- Most applicable:
  - Data span a range of annual nutrient loading rates.
  - Simple regression relationships are predictive.
  - Response variable (e.g., water clarity) related to biological endpoint, such as seagrass depth of colonization.
- Least applicable:
  - Little data available.
  - True relationships are too complex to resolve with regressions.
- What EPA is considering:

There are examples of stressor-response models that were useful.



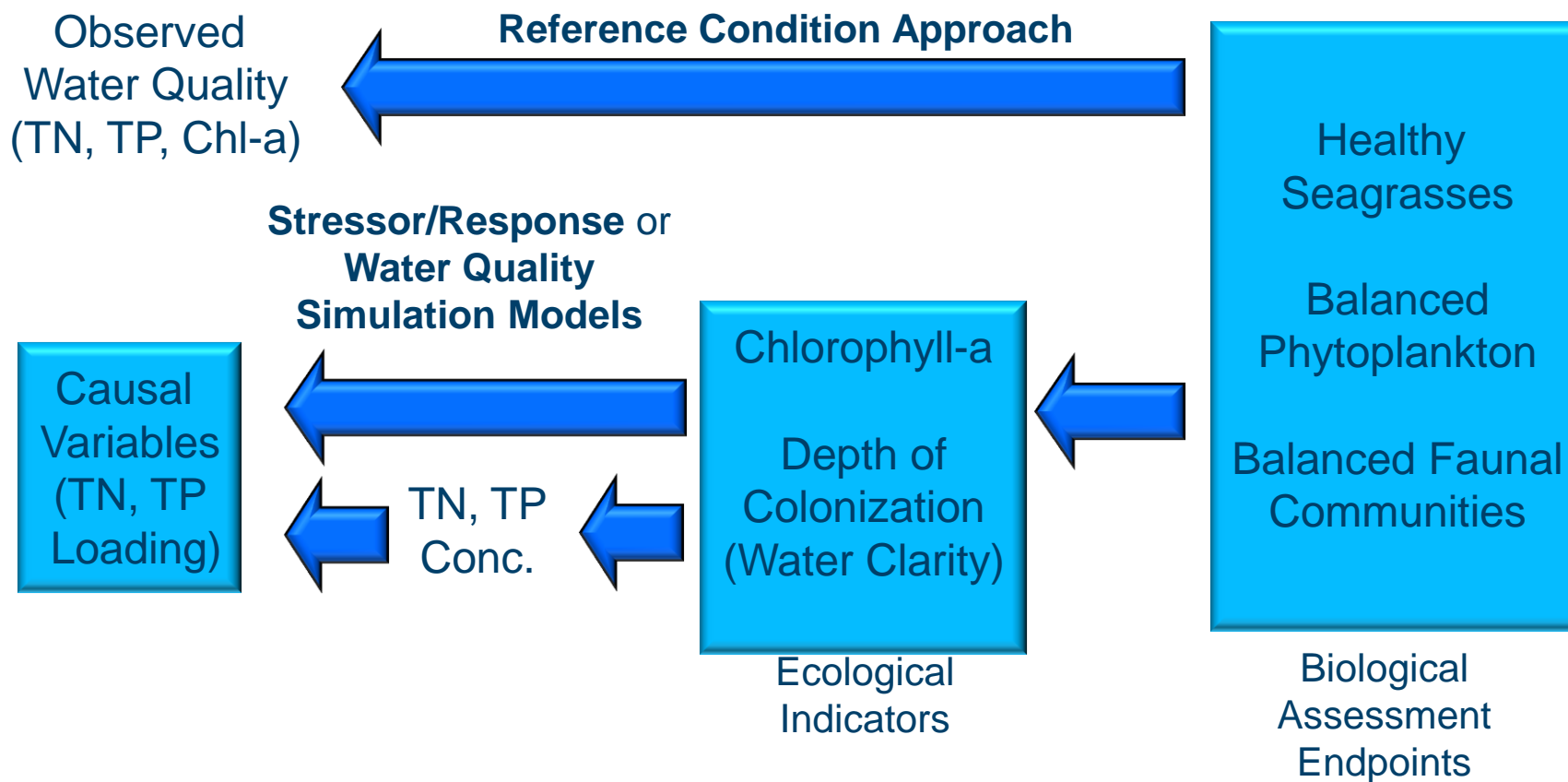
# Water Quality Simulation Models

- Most applicable:
  - Important ecosystem processes are well-understood.
  - Complex ecological interactions, physical-biological coupling, range of temporal/spatial scales.
  - Data are process-oriented, Concentrated in several years.
- Least applicable:
  - Poor understanding of important processes or mechanisms.
  - Too many model inputs are completely unknown.
  - Model can't predict the necessary endpoint.

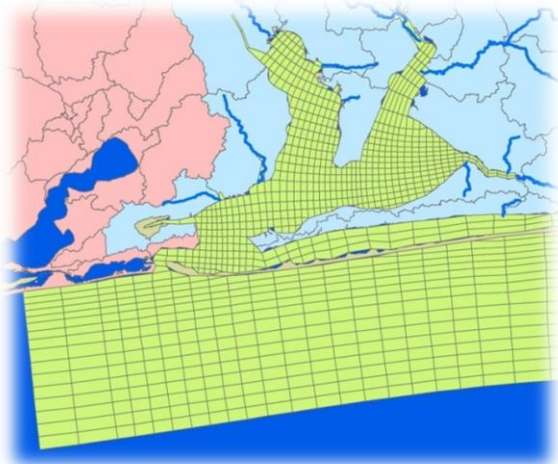
## What EPA is considering:

Water quality simulation models could be developed for many Florida estuaries. EPA will need to carefully evaluate model skill as well as other information.

# Criteria Development Approaches for Estuaries



# Example Using Watershed/ Water Quality Models



- Environmental Fluid Dynamics Code (EFDC) coupled with Water Quality Analysis Simulation Program (WASP)
- Model outputs related to biological endpoints.

Pensacola Bay EFDC/WASP Model Grid, coupled with watershed model.

Background  
Load

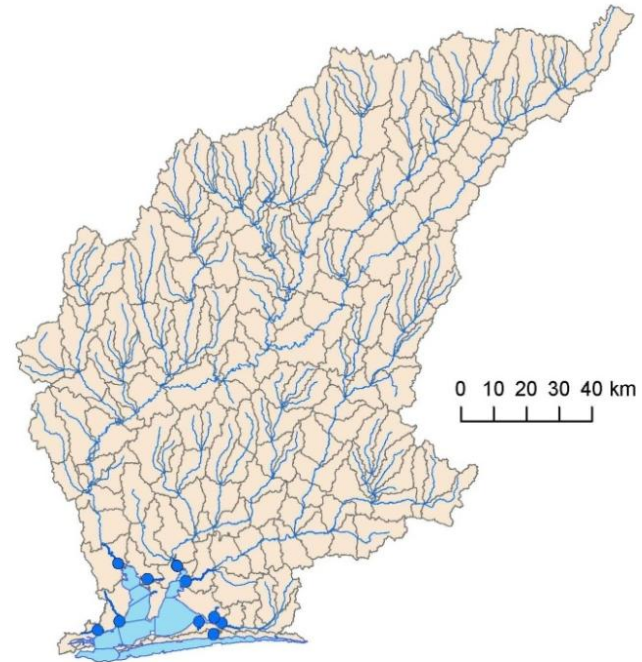
WQ consistent  
with Use Attainment

Current Loading  
(Calibration)



# Watershed Models

- EPA considering Loading Simulation Program in C++ (LSPC) for watershed modeling
- Watershed models simulate hydrology and water quality for 1997-2009 (13 years)
- Watershed model outputs are (1) inputs to estuary WQ models, (2) inputs for “dose-response” regression models relating loading to estuary WQ.
- “Background” scenarios involve returning land use to natural (forest, wetland) and removing point sources.



Pensacola Bay watershed model, with 224 sub-watersheds and associated stream reaches

# Water Quality Simulation Models

## State Variables

- Ammonia ( $\text{NH}_4^+$ )
- Nitrate plus nitrite ( $\text{NO}_3^- + \text{NO}_2^-$ )
- Inorganic phosphorus ( $\text{PO}_4^{3-}$ )
- Phytoplankton carbon & chl-a
- Diss. Organic Matter (C, N, P)
- Particulate detritus (C, N, P)
- Carbonaceous biological oxygen demand (CBOD)
- Dissolved Oxygen
- Total Suspended Solids

## Processes

- Phytoplankton production and mortality
- Light and nutrient limitation
- N and P uptake/recycling
- Sediment sinking
- Particulate C,N,P sinking

## Boundary Conditions

- Sediment oxygen demand and nutrient fluxes
- Gulf of Mexico concentrations
- Inflow concentrations
- $\text{NO}_3^-$  in rainfall



# Data Sources

- Diverse and potentially very large data requirements; matched by massive quantity of data that has been collected.
- Much data is available from local, state and Federal agencies, universities, and other entities.
- In section 2.4 we outlined the major data sources that EPA has obtained and is considering during criteria development.
  - Waterbody Delineation
  - Water Quality Monitoring Data
  - Land Use Data
  - Meteorological Data
  - General Hydrology
  - NPDES Point-Sources
  - Seagrass Coverage

## Data Sources

- Very large numbers in some estuaries (Tampa Bay, Charlotte Harbor, Indian River)
- Much less in others (Alligator Harbor, St. Joseph Bay)
- EPA working to identify additional data that is not IWR.

Water Quality Data in IWR 40 Database

	<b>TN</b>	<b>TP</b>	<b>Chl-a</b>
Tampa Bay	12,844	13,532	58,891
Charlotte Harbor	19,319	19,177	19,990
Indian River	8,191	10,912	37,429
Alligator Harbor	-	-	4
St. Joseph Bay	20	20	100
ALL	68,604 (1996-10)	71,836 (1996-10)	186,104 (1971-10)

## Chapter 3 Charge Questions

- a) Are the data sources identified appropriate for use in deriving numeric criteria in Florida's estuaries? Is the SAB aware of additional available, reliable data that EPA should consider in delineating estuaries or deriving criteria for estuarine waters?
- b) Are the assessment endpoints identified (healthy seagrass communities; balanced phytoplankton biomass and production; and balanced faunal communities) appropriate to translate Florida's narrative nutrient criterion into numeric criteria for Florida's estuaries, given currently available data? Does the SAB suggest modification or addition to these assessment endpoints.



Photo: Carl McCaskey.

## Chapter 3 Charge Questions

- a) EPA describes potential approaches in Section 3.3 (reference conditions, stressor response relationships, and water quality simulation models) for deriving numeric criteria for Florida's estuaries. Compare and contrast the potential of each approach to ensure the attainment and maintenance of natural populations of aquatic flora and fauna for different types of estuaries, given currently available data?